PROCEEDINGS OF SPIE

Free-Space Laser Communication Technologies XXIII

Hamid Hemmati

Editor

26–27 January 2011 San Francisco, California, United States

Sponsored and Published by SPIE

Volume 7923

The papers included in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. The papers published in these proceedings reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:

Author(s), "Title of Paper," in Free-Space Laser Communication Technologies XXIII, edited by Hamid Hemmati, Proceedings of SPIE Vol. 7923 (SPIE, Bellingham, WA, 2011) Article CID Number.

ISSN 0277-786X ISBN 9780819484604

Published by

SPIE

P.O. Box 10, Bellingham, Washington 98227-0010 USA Telephone +1 360 676 3290 (Pacific Time) Fax +1 360 647 1445 SPIE.org

Copyright © 2011, Society of Photo-Optical Instrumentation Engineers

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at copyright.com. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0277-786X/11/\$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.



Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon they are published online, and connects the same identifier to all online, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc.

The CID number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages. Numbers in the index correspond to the last two digits of the six-digit CID number.

Contents

Conference Committee

IX	Microtabrication by optical tweezers (Plenary Paper) [792102] R. Ghadiri, T. Weigel, C. Esen, A. Ostendorf, Ruhr-Univ. Bochum (Germany)			
SESSION 1	INVITED SESSION			
7923 02	Overview of the lunar laser communications demonstration (Invited Paper) [7923-01] B. S. Robinson, D. M. Boroson, D. A. Burianek, D. V. Murphy, MIT Lincoln Lab. (United States)			
7923 03	Coherent inter-satellite and satellite-ground laser links (Invited Paper) [7923-02] M. Gregory, F. Heine, H. Kämpfner, R. Lange, Tesat-Spacecom GmbH & Co. KG (German M. Lutzer, R. Meyer, DLR, German Aerospace Ctr. (Germany)			
7923 05	Tactical network demonstration with free space lasercomm (Invited Paper) [7923-04] H. R. Burris, M. S. Ferraro, U.S. Naval Research Lab. (United States); W. Freeman, SmartLogic Inc. (United States); P. G. Goetz, R. Mahon, C. I. Moore, J. L. Murphy, J. Overfield, W. S. Rabinovich, W. R. Smith, M. R. Suite, L. M. Thomas, B. B. Xu, U.S. Naval Research Lab. (United States)			
7923 06	Orbital angular momentum (OAM) based LDPC-coded deep-space optical communication (Invited Paper) [7923-05] I. B. Djordjevic, The Univ. of Arizona (United States)			
7923 07	Architecture, design, and numerical simulation of a code/pulse-position-swapping (CPPS) direct translating receiver (Invited Paper) [7923-06] A. J. Mendez, Mendez R&D Associates (United States); V. J. Hernandez, C. V. Bennett, Lawrence Livermore National Lab. (United States); R. M. Gagliardi, The Univ. of Southern California (United States)			
SESSION 2	MODEM AND CODING			
7923 08	Design of a high-speed space modem for the lunar laser communications demonstration [7923-07] S. Constantine, L. E. Elgin, M. L. Stevens, J. A. Greco, K. Aquino, D. D. Alves, B. S. Robinson, MI Lincoln Lab. (United States)			
7923 09	Characterization of chaos generated by bistable optical systems with a nonlinearity of form sin²(x) [7923-08] A. K. Ghosh, P. Verma, The Univ. of Oklahoma (United States)			
7923 0A	Modulated laser radar decoding by inter symbol interference [7923-09] X. Mao, D. Inoue, H. Matsubara, M. Kagami, Toyota Central Research and Developme Labs., Inc. (Japan)			

SESSION 3	FUTURE SYSTEMS					
7923 OB	Study of optical inter-orbit communication technology for next generation space data-relay satellite [7923-10] T. Hanada, S. Yamakawa, H. Kohata, Japan Aerospace Exploration Agency (Japan)					
7923 0C	Deep-space optical terminals (DOT) [7923-11] H. Hemmati, W. H. Farr, A. Biswas, K. M. Birnbaum, W. T. Roberts, K. Quirk, S. Townes, Jet Propulsion Lab. (United States)					
SESSION 4	LASERS					
7923 0D	Fiber-MOPA based multi-kW uplink laser beacons for deep-space communication links [7923-12] D. Engin, W. Lu, F. Kimpel, Y. Chen, M. Akbulut, S. Gupta, Fibertek, Inc. (United States)					
7923 OG	Absolute time position of picosecond laser pulse [7923-15] J. Blazej, I. Prochazka, J. Kodet, Czech Technical Univ. in Prague (Czech Republic)					
SESSION 5	RECEIVERS					
7923 OJ	Coherent homodyne receiver with a compensator of Doppler shifts for inter orbit optical communication [7923-18] T. Ando, E. Haraguchi, K. Tajima, Y. Hirano, Mitsubishi Electric Corp. (Japan); T. Hanada, S. Yamakawa, Japan Aerospace Exploration Agency (Japan)					
7923 OK	Deep space uplink receiver prototype for optical communications [7923-19] S. E. Sburlan, K. M. Birnbaum, W. H. Farr, Jet Propulsion Lab. (United States)					
SESSION 6	POINTING, ACQUISITION, TRACKING					
7923 OL	Design of an inertially stabilized telescope for the LLCD [7923-20] J. W. Burnside, S. D. Conrad, A. D. Pillsbury, C. E. DeVoe, MIT Lincoln Lab. (United States)					
7923 OM	High-performance two-axis gimbal system for free space laser communications onboard unmanned aircraft systems [7923-22] M. Locke, M. Czarnomski, A. Qadir, B. Setness, N. Baer, J. Meyer, W. H. Semke, The Univ. of North Dakota (United States)					
7923 ON	Optical inter-satellite communication with dynamically reconfigurable optical device using \$n_2P_2S_6 crystal [7923-23] K. Nishimaki, A. Okamoto, T. Fujita, Hokkaido Univ. (Japan); A. A. Grabar, Uzhgorod National Univ. (Ukraine); M. Takabayashi, Hokkaido Univ. (Japan); J. Uozumi, Hokkai-Gakuen Univ. (Japan); A. Tomita, Hokkaido Univ. (Japan); Y. Takayama, National Institute of Information and Communications Technology (Japan)					

SESSION 7	ATMOSPHERICS				
7923 00	Operational condition of direct single-mode-fiber coupled FSO terminal under strong atmospheric turbulence [7923-24] Y. Arimoto, National Institute of Information and Communications Technology (Japan)				
7923 OP	Experimental analysis of the effects of atmospheric turbulence on a 29-km free-space laser communication link [7923-25] V. Nikulin, Binghamton Univ. (United States); J. Malowicki, Air Force Research Lab. (United States); V. Bedi, Binghamton Univ. (United States); D. Hughes, H. Bloss, Air Force Research Lab. (United States)				
7923 0Q	Performance analysis of atmospheric field conjugation adaptive arrays [7923-26] A. Belmonte, Technical Univ. of Catalonia (Spain); J. M. Kahn, Stanford Univ. (United States)				
7923 OR	Study on the implementation of spatial light modulator liquid crystal device atmospheric simulator for short wavelength infrared applications [7923-27] F. Santiago, C. O. Font, C. C. Wilcox, T. Martinez, U.S. Naval Research Lab. (United States); S. Myers, Ctr. for High Technology Materials (United States); J. A. Duperre III, J. R. Andrews, S. R. Restaino, C. Gilbreath, U.S. Naval Research Lab. (United States); D. Payne, Narrascape, Inc. (United States)				
SESSION 8	RANGING				
7923 OS	Field demonstrations of active laser ranging with sub-mm precision [7923-28] Y. Chen, K. M. Birnbaum, H. Hemmati, Jet Propulsion Lab. (United States)				
	Author Index				

Conference Committee

Symposium Chairs

Friedhelm Dorsch, TRUMPF GmbH & Company KG (Germany) **Alberto Piqué**, Naval Research Laboratory (United States)

Symposium Cochairs

Donald J. Harter, IMRA America, Inc. (United States) **Peter R. Herman**, University of Toronto (Canada)

Conference Chair

Hamid Hemmati, Jet Propulsion Laboratory (United States)

Program Committee

Don M. Boroson, MIT Lincoln Laboratory (United States)
 Vincent W. Chan, Massachusetts Institute of Technology (United States)
 G. Charmaine C. Gilbreath, U.S. Naval Research Laboratory (United States)

Michael A. Krainak, NASA Goddard Space Flight Center (United States)

Robert Lange, Tesat-Spacecom GmbH & Company KG (Germany)
Zoran Sodnik, European Space Research and Technology Center (Netherlands)

Morio Toyoshima, National Institute of Information and Communications Technology (Japan)

Alan E. Willner, The University of Southern California (United States) **Shiro Yamakawa**, Japan Aerospace Exploration Agency (Japan)

Session Chairs

- Invited Session
 Hamid Hemmati, Jet Propulsion Laboratory (United States)
- 2 Modem and Coding Robert Lange, Tesat-Spacecom GmbH & Company KG (Germany)
- 3 Future Systems
 Robert Lange, Tesat-Spacecom GmbH & Company KG (Germany)

4 Lasers
Michael A. Krainak, NASA Goddard Space Flight Center (United States)

ReceiversWilliam H. Farr, Jet Propulsion Laboratory (United States)

6 Pointing, Acquisition, Tracking **Don M. Boroson**, MIT Lincoln Laboratory (United States)

7 Atmospherics **Don M. Boroson**, MIT Lincoln Laboratory (United States)

8 RangingDon M. Boroson, MIT Lincoln Laboratory (United States)